INDOOR AIR QUALITY ASSESSMENT

Norton Middle School
215 West Main Street
Norton, MA 02766

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of the Norton School Department, the Massachusetts Department of Public Health (MDPH) Center for Environmental Health (CEH) provided assistance and consultation regarding indoor air quality at the Norton Middle School (NMS), 215 West Main Street, Norton, Massachusetts. This assessment was conducted as part of ongoing efforts by the Norton School and health departments to improve indoor air quality in schools. With the completion of the NMS assessment, CEH has conducted assessments in all schools in the Norton Public School system.

On December 15, 2005, Cory Holmes, an Environmental Analyst in CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program, conducted an assessment at the NMS. Mr. Holmes was accompanied by Manuel Texieria, Head Custodian, for portions of the assessment.

The NMS is a three-story, red brick building constructed in 1998. The school contains two main wings forming a 'V', with a centralized rotunda at the base of the V shape. The classroom wing contains general classrooms, science classrooms, resource rooms, the library and computer labs. The other wing contains art rooms, music rooms, auditorium, kitchen/cafeteria, gymnasium, locker rooms, office space, technical education classrooms and life skills classrooms. Windows are openable throughout the building.

Methods

Air tests for carbon dioxide, carbon monoxide, temperature and relative humidity were conducted with the TSI, Q-TRAK™ IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). CEH staff also performed a visual inspection of building materials for water damage and/or microbial growth.

Results

The school houses approximately 800 students in grades 6-8 with approximately 60 staff members. Tests were taken during normal operations at the school and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million (ppm) parts of air in 27 of 53 areas surveyed, indicating poor air exchange in about half of the areas surveyed (mainly in the classroom wing) during the assessment. A heating, ventilation and air conditioning (HVAC) system controlled by a computer system provides ventilation. Fresh air is provided by rooftop-mounted air handling units (AHUs) (Picture 1). These AHUs are connected to ducts that supply fresh air to rooms through ceiling mounted air diffusers (Picture 2 and 3). By design, air diffusers are equipped with fixed louvers, which create airflow by directing the air supply along the ceiling to flow down the walls.

Local airflow to each air diffuser is controlled by a variable air volume (VAV) box. Each VAV box has a set of thermostat-controlled dampers that open or close depending on the temperature demand for a serviced area. Once the thermostat detects that the temperature has reached a predetermined level, the VAV box dampers close until heating or cooling is needed. VAV boxes also control the provision of fresh air to a serviced space. During times that the temperature of a space is adequate, the VAV box closes its damper and limits the amount of fresh air. In contrast, if the thermostat calls for the HVAC system to provide heat, the AHU fresh air intake damper would close to increase the temperature of the air in the ductwork and occupied spaces. Airflow would be noted from the ceiling air diffusers because the VAV box dampers are open, but fresh air supply would be limited by the closing of the rooftop fresh air intake damper.

While it has the advantage of energy conservation and lower operating costs, VAV box systems may cause problems of insufficient outside air supply. For example, once the temperature requirement is met, airflow drops. Airflow can drop to zero in poorly performing HVAC systems (Plog, Niland and Quinlan, 1996). Please note that this condition may occur during times of outdoor temperature extremes ($< 32^{o}$ F or $>90^{o}$ F). Air monitoring was conducted on a day with comfortable outdoor conditions (72^{o} F). To ascertain whether minimal airflow conditions exist, air monitoring during temperature extremes should be considered. Air is returned back to rooftop AHUs via ceiling or wall-mounted return vents (Picture 4).

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The mechanical ventilation systems at NMS were reportedly balanced prior to occupancy of the 1998-1999 school year.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room

(SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, consult Appendix A.

Temperature measurements ranged from 67° F to 75° F, with several areas slightly below the MDPH recommended comfort range. The MDPH recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in the building ranged from 13 to 23 percent, which was below the MDPH recommended comfort range in all areas the day of the assessment. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Mr. Texieria reported that the rotunda has experienced chronic leaks over the years resulting in peeling paint and water damage to interior walls (Pictures 5 and 6). Water penetration through the building envelope can lead to mold growth in porous building materials. In addition, a few areas had water-damaged ceiling tiles (Picture 7/Table 1), which can indicate leaks from either the roof or plumbing system. Water-damaged ceiling tiles can provide a source of mold and should be replaced after a water leak is discovered and repaired.

Spaces between the sink countertop and backsplash were noted in several classrooms (Picture 8/Table 1). Improper drainage or sink overflow can lead to water penetration to countertop wood, the cabinet interior and areas behind cabinets. Like other porous materials, if these materials become wet repeatedly they can provide a medium for mold growth.

Several classrooms had a number of plants. Moistened plant soil and drip pans can be a source of mold growth. Plants should be equipped with drip pans. The absence of drip pans can lead to water pooling and mold growth. Plants are also a source of pollen. Plants should be located away from the air stream of ventilation sources to prevent the aerosolization of mold, pollen or particulate matter throughout the classroom.

Lastly, several rooms contained aquariums and terrariums. Aquariums and terrariums should be properly maintained to prevent bacterial growth, mold growth and nuisance odors.

Other IAQ Evaluations

Indoor air quality can be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, MDPH staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide pollution and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from 6 criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Carbon monoxide levels measured outside the school were non-detectable (ND). For the NMS, indoor carbon monoxide concentrations were non-detect or ND in all areas, with the exception of the life skills room (C-5), which had a slight reading of 2 ppm while operating gas dryers and stoves.

As previously mentioned, the US EPA also established NAAQS for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent PM2.5 standard requires outdoor air particulate levels be maintained below 65 $\mu g/m^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, MDPH uses the more protective PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 26 $\mu g/m^3$ (Table 1). PM2.5 levels measured indoors ranged from 5 to 26 $\mu g/m^3$, which were below the NAAQS PM2.5 level of 65 $\mu g/m^3$ in all areas surveyed. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner; and heavy foot traffic indoors.

Indoor air quality can also be impacted by the presence of materials containing volatile organic compounds (VOCs). VOCs are substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were ND (Table 1). Indoor TVOC measurements throughout the building were also ND.

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC-containing products. While no measurable TVOC levels were detected in the indoor environment, VOC-containing materials were noted. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Several other conditions that can affect indoor air quality were noted during the assessment. In several classrooms, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up. A number of exhaust vents and personal fans in classrooms had accumulated dust (Pictures 18 and 19). If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize dust particles. Dust particles can also be aerosolized when fans are activated. Dust can be irritating to eyes, nose and respiratory tract.

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Continue to operate both supply and exhaust ventilation continuously during periods of school occupancy to maximize air exchange. Consult the school's heating, ventilation and air conditioning (HVAC) engineer concerning an increase in the introduction of outside air in areas indicated in Table 1.
2. Consider having the ventilation system balanced by an HVAC engineer every five years (SMACNA, 1994).
3. Close classroom doors to maximize air exchange.

4. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
5. Ensure roof/plumbing leaks are repaired and replace water damaged ceiling tiles. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
6. Contact a building envelope specialist and/or architectural firm to examine methods to prevent water infiltration through the rotunda. Once repaired replace water damaged building materials.
7. Seal areas around sinks to prevent water-damage to the interior of cabinets and adjacent wallboard.
8. Clean/maintain aquariums/terrariums to prevent mold/bacterial growth and associated odors.
9. Ensure all plants are equipped with drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.
10. Clean personal fans, air diffusers and exhaust/return vents periodically of accumulated dust.

11. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

12. Consider adopting the US EPA (2000) document, "Tools for Schools", as an instrument for maintaining a good indoor air quality environment in the building. This document is available at: http://www.epa.gov/iaq/schools/index.html.

13. Refer to resource manual and other related indoor air quality documents located on the MDPH's website for further building-wide evaluations and advice on maintaining public buildings. These documents are available at: http://mass.gov/dph/indoor_air

References

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US EPA. 2000b. Tools for Schools. Office of Air and Radiation, Office of Radiation and Indoor Air, Indoor Environments Division (6609J). EPA 402-K-95-001, Second Edition. http://www.epa.gov/iaq/schools/tools4s2.html

Picture 1

Rooftop Air Handling Unit

Picture 2

Multi-Directional Air Diffuser

Picture 3

Slotted Air Diffuser

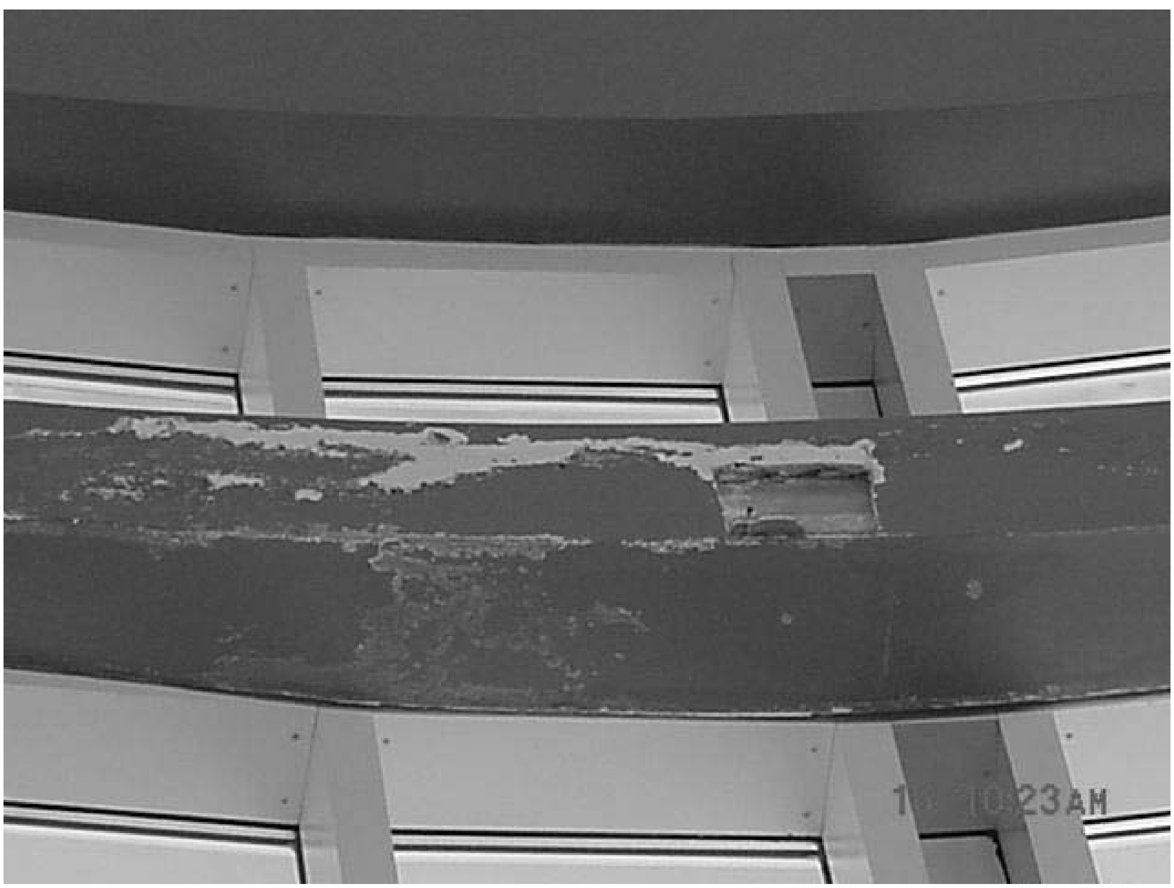
Picture 4

Ceiling-Mounted Return Vent

Picture 5

Exterior View of Rotunda

Picture 6



Interior Shot of Peeling Paint/Water Damage to Rotunda

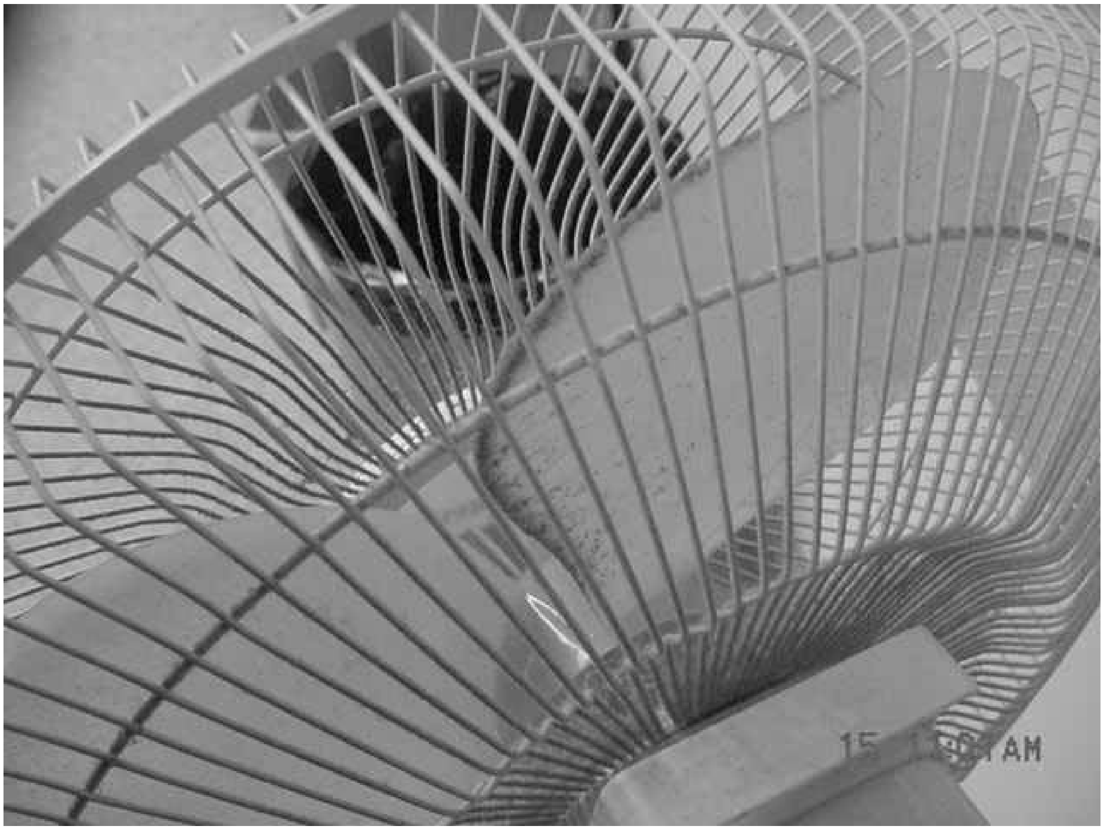
Picture 7

Water Damaged Ceiling Tile

Picture 8

Space between Sink Countertop and Backsplash

Picture 9



Dust Accumulation on Fan Blades in Classroom

Norton Middle School

215 West Main Street, Norton, MA 02766

Table 1

Indoor Air Results

Date: 12/15/2005

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
background	0	38	16	408	ND	ND	26	N			cold, clear skies-sunny, winds light and variable.
auditorium	0	69	15	674	ND	ND	5	N	Y ceiling	Y wall	Hallway DO,
band/chorus	8	69	14	609	ND	ND	17	N	Y ceiling	Y ceiling	DEM.
boy's locker room	0	67	14	510	ND	ND	15	Y # open: 0 # total: 5	Y ceiling	Y ceiling	DEM, 25 occupants gone 5 mins.
C-1 Art	19	71	16	769	ND	ND	12	Y # open: 0 # total: 6	Y ceiling	Y ceiling	Inter-room DO, kiln, DEM.
C-4	17	71	15	795	ND	ND	14	Y # open: 0 # total: 4	Y ceiling	Y ceiling	DEM.
C-5	17	70	19	1217	2	ND	13	Y # open: 0 # total: 7	Y ceiling	Y ceiling	clothing dryer, DEM, gas stoves.

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
VL = vent location
WP = wall plaster

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
	> 800 ppm = indicative of ventilation problems		

Norton Middle School **Indoor Air Results**

215 West Main Street, Norton, MA 02766 **Date: 12/15/2005**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
C-6	14	70	14	684	ND	ND	16	Y # open: 0 # total: 7	Y ceiling	Y ceiling	Hallway DO, DEM, PF.
C-8 Music	17	70	14	646	ND	ND	16	Y # open: 0 # total: 5	Y ceiling	Y ceiling	
cafeteria	300	70	23	1239	ND	ND	11	Y # open: 0 # total: 18	Y ceiling	Y ceiling	Hallway DO,
computer lab B	0	73	13	566	ND	ND	5	Y # open: 0 # total: 6	Y ceiling	Y ceiling	DEM.
girl's locker room	0	68	15	723	ND	ND	16	Y # open: 0 # total: 2	Y ceiling	Y ceiling	DEM, 25 occupants gone 5 mins.
guidance reception	1	70	15	661	ND	ND	6	N	Y ceiling	Y ceiling	temperature complaints (cold).
gym	50	68	17	693	ND	ND	7	N	Y ceiling	Y wall	

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Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

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Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
library	50	71	13	663	ND	ND	5	Y # open: 0 # total: 6	Y ceiling wall	Y ceiling	#WD-CT: 1, plants.
music	0	68	14	598	ND	ND	20	N	Y ceiling	Y ceiling	
Nurse	1	72	13	583	ND	ND	16	Y # open: 0 # total: 4	Y ceiling	Y ceiling	breach sink/counter, plants.
testing room	2	73	14	645	ND	ND	14	N	Y ceiling	Y ceiling	Hallway DO, thermostat hanging from wall by wire.
101	0	71	18	649	ND	ND	17	N	Y ceiling	Y ceiling	Hallway DO, breach sink/counter, DEM, PF.
102	30	72	17	1007	ND	ND	17	Y # open: 0 # total: 2	Y ceiling	Y ceiling	Hallway DO, breach sink/counter, DEM, PF.
103	25	73	17	991	ND	ND	19	Y # open: 0 # total: 5	Y ceiling	Y ceiling	Hallway DO, DEM.

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									Supply	Exhaust	
104	34	74	19	1135	ND	ND	21	Y # open: 0 # total: 4	Y ceiling	Y ceiling	breach sink/counter, DEM.
105	22	74	16	820	ND	ND	19	Y # open: 0 # total: 4	Y ceiling	Y ceiling	breach sink/counter, DEM, PF.
106	31	72	16	835	ND	ND	23	Y # open: 0 # total: 4	Y ceiling	Y ceiling	
122	30	74	20	1206	ND	ND	17	Y # open: 0 # total: 5	Y ceiling	Y ceiling	DEM.
124	28	74	18	1046	ND	ND	18	Y # open: 0 # total: 4	Y ceiling	Y ceiling	Hallway DO, DEM.
125	26	73	17	906	ND	ND	18	Y # open: 0 # total: 4	Y ceiling	Y ceiling	Hallway DO, DEM.
126	6	73	16	786	ND	ND	16	Y # open: 0 # total: 4	Y ceiling	Y ceiling	Hallway DO, DEM.

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									Supply	Exhaust	
130	4	69	13	560	ND	ND	15	Y # open: 0 # total: 4	Y ceiling	Y ceiling	Hallway DO, breach sink/counter, DEM.
132	2	71	13	515	ND	ND	15	Y # open: 0 # total: 4	Y ceiling	Y ceiling	Hallway DO, DEM, 10 occupants gone 30 mins.
133	7	72	13	571	ND	ND	17	N	Y ceiling	Y ceiling	Hallway DO, DEM, PF, items.
201	23	72	16	958	ND	ND	19	Y # open: 0 # total: 0	Y ceiling	Y ceiling	breach sink/counter, DEM, PF.
202	1	72	14	680	ND	ND	19	Y # open: 0 # total: 4	Y ceiling	Y ceiling	Hallway DO, breach sink/counter, DEM, plants, 15 occupants gone 15 mins.
203	23	74	16	946	ND	ND	19	Y # open: 0 # total: 5	Y ceiling	Y ceiling	breach sink/counter, DEM.
204	28	73	17	859	ND	ND	17	Y # open: 1 # total: 7	Y ceiling	Y ceiling	Hallway DO, breach sink/counter, PF.

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215 West Main Street, Norton, MA 02766 **Date: 12/15/2005**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
205	25	75	15	829	ND	ND	20	Y # open: 0 # total: 6	Y ceiling	Y ceiling	breach sink/counter, DEM, PF.
206	25	75	15	889	ND	ND	18	Y # open: 0 # total: 4	Y ceiling	Y ceiling	Hallway DO, DEM.
221	24	72	19	1259	ND	ND	19	Y # open: 0 # total: 4	Y ceiling	Y ceiling	Hallway DO, DEM.
224	24	74	18	1087	ND	ND	17	Y # open: 0 # total: 6	Y ceiling	Y ceiling	DEM.
225	22	75	16	860	ND	ND	16	Y # open: 0 # total: 6	Y ceiling	Y ceiling	Hallway DO, breach sink/counter, DEM, PF.
226	26	74	16	890	ND	ND	15	Y # open: 0 # total: 4	Y ceiling	Y ceiling	Hallway DO, breach sink/counter, DEM, aqua/terra, plants, reports of noise from exhaust vent by occupant.

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
VL = vent location
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Norton Middle School **Indoor Air Results**

215 West Main Street, Norton, MA 02766 **Table 1** **Date: 12/15/2005**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
301	25	70	22	321	ND	ND	26	Y # open: 0 # total: 4	Y ceiling	Y ceiling	Hallway DO, #WD-CT: 2, breach sink/counter, DEM.
302	26	72	19	926	ND	ND	20	Y # open: 0 # total: 4	Y ceiling	Y ceiling	DEM, plants.
303	24	72	18	969	ND	ND	21	Y # open: 0 # total: 6	Y ceiling	Y ceiling	DEM, PF.
304	1	75	17	856	ND	ND	18	Y # open: 0 # total: 7	Y ceiling	Y ceiling	Hallway DO, breach sink/counter, 25 occupants gone 2 mins.
305	1	74	16	829	ND	ND	22	Y # open: 0 # total: 6	Y ceiling	Y ceiling	PF, 25 occupants gone 4 mins.
306	2	74	16	823	ND	ND	21	Y # open: 0 # total: 4	Y ceiling	Y ceiling	Hallway DO, #WD-CT: 3, plants, 26 occupants gone 5 mins, noisy vent .
321	22	71	15	794	ND	ND	19	Y # open: 0 # total: 4	Y ceiling	Y ceiling	Hallway DO, #WD-CT: 1, DEM, PF, nests.

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Norton Middle School

215 West Main Street, Norton, MA 02766

Table 1

Indoor Air Results

Date: 12/15/2005

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
323	24	71	16	826	ND	ND	16	Y # open: 0 # total: 5	Y ceiling	Y ceiling	Hallway DO, #WD-CT: 6, breach sink/counter, DEM, PF.
324	25	74	15	846	ND	ND	16	Y # open: 0 # total: 6	Y ceiling	Y ceiling	Hallway DO, DEM, PF.
325	22	74	16	874	ND	ND	17	Y # open: 0 # total: 6	Y ceiling	Y ceiling	Hallway DO, DEM, PF.
326	26	74	16	773	ND	ND	19	Y # open: 0 # total: 4	Y ceiling	Y ceiling	Hallway DO, breach sink/counter, DEM, plants, mold experiments-food.
330	0	71	13	578	ND	ND	16	Y # open: 0 # total: 6	Y ceiling	Y ceiling	Hallway DO, breach sink/counter, DEM.
333	1	69	14	585	ND	ND	17	Y # open: 0 # total: 6	Y ceiling	Y ceiling	Hallway DO, PF, temperature complaints (cold).

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